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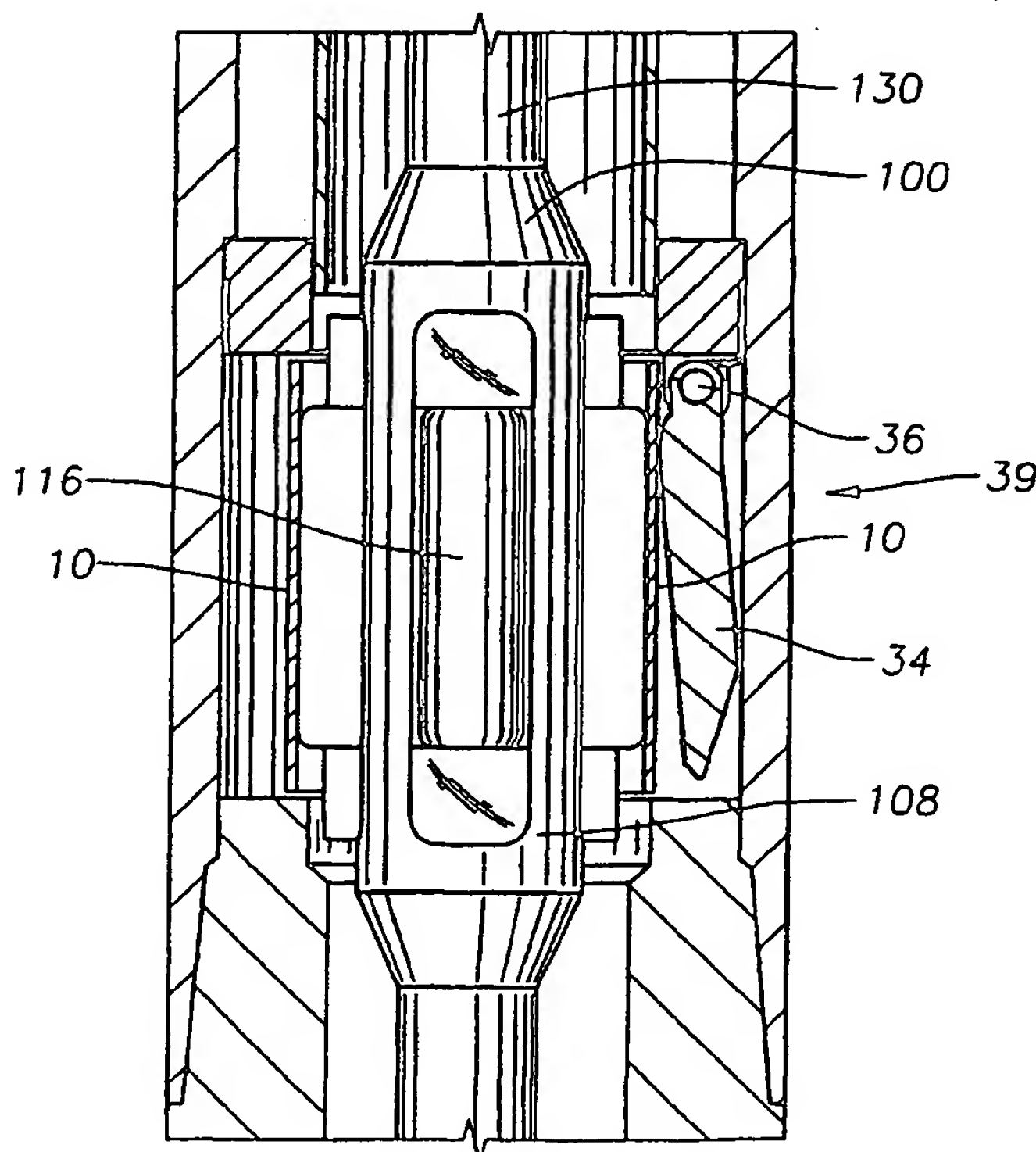
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- (71) Applicant (for all designated States except US): WEATHERFORD/LAMB, INC. [US/US]; 515 Post Oak Blvd, Suite 600, Houston, TX 77027 (US).
- (71) Applicant (for IS only): HARDING, Richard, Patrick [GB/GB]; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): HILL, Thomas, G. [US/US]; 1426 Lofty Maple Trail, Kingwood, TX 77345 (US). ANDERSON, Robert, James [GB/GB]; 34 Hillview Terrace, Cults, Aberdeen, Aberdeenshire AB15 9HJ (GB).
- (74) Agent: TALBOT-PONSONBY, Daniel; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).
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(54) Title: EXPANDABLE LOCKOUT FOR A SUBSURFACE SAFETY VALVE



(57) Abstract: A locking assembly for a wellbore valve (39) is provided comprising a cylindrical expandable sleeve (10) insertable into an interior of the valve. After insertion into the valve, the body is expanded into interference with a closing mechanism (34) of the valve (39), thereby locking the valve (39) in an open position.

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EXPANDABLE LOCKOUT FOR A SUBSURFACE SAFETY VALVE

The invention relates to methods and apparatus for locking a wellbore valve in an open position. More particularly, the invention relates to methods and apparatus for permanently locking a subsurface safety valve in an open position through the use of expandable tubulars.

For oil and gas wells, especially those that operate offshore, redundant safety devices typically include a valve located about 500 feet (152 m) below the ocean mud line sealably connected to the production tubing string through which production fluids pass. The valve, typically referred to as a subsurface safety valve, ensures that if the fluid conduit between the ocean floor and the platform is disrupted (by a passing vessel for instance) that the flow of production fluid from the sub-sea well head will be cut off and the ocean will not be contaminated with production fluid. If the subsurface safety valve malfunctions during its operational life, it may become necessary to permanently lock out the valve in an open position. This is particularly necessary when the safety valve has malfunctioned and closed, commonly due to a control line break or hydraulic chamber leak. The most common type of subsurface safety valve in use in subterranean wells today is the "surface controlled subsurface safety valve", commonly and hereinafter referred to as an SCSSV. SCSSVs are required by regulatory agencies in all offshore wells worldwide. SCSSVs may also be used in land wells where the risk of wellhead damage and uncontrolled blowout of the well is high. Examples of subsurface safety valves include flapper (as shown in Figure 6), ball (as shown in Figure 7), and annulus type valves. Safety valves are typically actuated by a reciprocating flow tube or choke. In the case of a flapper type valve, the flapper pivots about a hinge to close and block the flow of fluid through the valve. In essence, SCSSVs are "normally closed" downhole valves which are operated by pressurized hydraulic fluid in a small diameter control line extending from an actuator integral to the valve to a control panel on the earth's surface. Pressure in the control line exerted by the control panel holds the SCSSV in the open position, permitting fluid to pass through the valve and to the surface of the well for collection. Disruption of that pressure for any reason causes the valve to close. For example, if a control line or hydraulic seal failure occurs, loss of

hydraulic pressure causes inadvertent closure of the flapper.

Valves, including SCSSVs, may be held in an open position by placing a spring metal band which expands from a contracted, run-in position to a radially enlarged locking position adjacent the flapper thereby holding the valve member open. For example, U.S. Pat. No. 4,577,694, which is hereby incorporated by reference, discloses a running tool that holds a metal band spring in the collapsed position for placement in the well. When released, the spring expands into contact with the valve member, thereby holding it in the open position. One disadvantage to a metal band spring is that hydrocarbons flowing past the metal band spring cause eddies and low pressure areas that can cause the spring to inadvertently collapse and flow upward with production. This action can permit the "permanently locked out" SCSSV to inadvertently shut, thereby stopping the flow of hydrocarbons from the well. This results in costly remedial workover operations and lost production.

Other methods of locking out the SCSSV include incorporation of a lockout device integrally into a valve actuating mechanism. However, this solution complicates the design and adds to the total cost of the valve. An example of this type of lockout mechanism is described in U.S. Patent No. 4,624,315, which is hereby incorporated by reference. Because of the high degree of reliability and longevity of modern SCSSVs, the need arises very infrequently for locking most SCSSVs open. Furthermore, the integral lock open mechanism has an adverse effect on the reliability of the SCSSV by being continuously subjected to subsurface well conditions during normal operations. As such, it may be damaged, corroded or stuck in the retracted position, preventing a necessary lock open operation when required.

Insertable locking devices for safety valves are also hampered by the physical characteristics of wellbores. Wellbores and inside diameters thereof vary greatly from well to well. Also, the inside diameter of a wellbore may vary at different depths. The "drift" diameter of a wellbore refers to a maximum diameter of a length of bar that will pass unimpeded through the inside diameter of a wellbore. Any insertable locking device must therefore meet limitations in space inherent in a particular wellbore.

One attempt to compensate for variable physical characteristics of a wellbore has been to utilize expandable tubular technology. Both slotted and solid tubulars can be expanded *in situ* to enlarge a fluid path through the tubular and also to fix a smaller tubular within the inner diameter of a larger tubular therearound. Tubulars are expanded by the use of a cone-shaped mandrel or by an expansion tool with expandable, fluid actuated members disposed on a body and run into the wellbore on a tubular string. During expansion of a tubular, the tubular walls are expanded past their elastic limit. Examples of expandable tubulars include slotted screen, joints, packers, and liners. Figures 1a and 1b are perspective and cross-sectional views of an exemplary expansion tool 100 and Figure 1c is an exploded view thereof. The expansion tool 100 has a body 102 which is hollow and generally tubular with connectors 104 and 106 for connection to other components (not shown) of a downhole assembly. The connectors 104 and 106 are of a reduced diameter (compared to the outside diameter of the longitudinally central body part 108 of the tool 100), and together with three longitudinal flutes 110 on the central body part 108, allow the passage of fluids between the outside of the tool 100 and the interior of a tubular therearound (not shown). The central body part 108 has three lands 112 defined between the three flutes 110, each land 112 being formed with a respective recess 114 to hold a respective roller 116. Each of the recesses 114 has parallel sides and extends radially from the radially perforated tubular core 115 of the tool 100 to the exterior of the respective land 112. Each of the mutually identical rollers 116 is near-cylindrical and slightly barreled. Each of the rollers 116 is mounted by means of a bearing 118 at each end of the respective roller for rotation about a respective rotational axis which is parallel to the longitudinal axis of the tool 100 and radially offset therefrom at 120-degree mutual circumferential separations around the central body 108. The bearings 118 are formed as integral end members of radially slidable pistons 120, one piston 120 being slidably sealed within each radially extended recess 114. The inner end of each piston 120 (Figure 1a) is exposed to the pressure of fluid within the hollow core of the tool 100 by way of the radial perforations in the tubular core 115. In this manner, pressurized fluid provided from the surface of the well, via a tubular, can actuate the pistons 120 and cause them to extend outward and to contact the inner wall of a tubular to be expanded.

Therefore, a need exists to provide a method and apparatus for permanently holding

open the SCSSV by a mechanism which is entirely separate from the SCSSV mechanism, and one which would not tend to flow out of position during production operations. Additionally, a need exists to provide a lockout sleeve device utilizing expandable tubular technology which can be subsequently inserted in the well conduit
5 only when it becomes necessary to permanently lock the SCSSV in an open position.

In one aspect of the invention, a locking assembly for a wellbore valve is provided comprising a cylindrical sleeve insertable into an interior of the valve. After insertion into the valve, the body is expanded into interference with a closing mechanism of the
10 valve, thereby locking the valve in an open position.

In one embodiment, a method and apparatus for locking out a safety valve in a wellbore is provided in which a tubular, or a lockout sleeve, having an outer diameter substantially equal to or less than a drift diameter of the wellbore and an expansion tool
15 are placed in the wellbore. The safety valve is located and the lockout sleeve and expansion tool are landed adjacent the safety valve. With the valve in an open position, the lockout sleeve and the expansion tool are positioned within an inner diameter thereof. The expansion tool is energized causing extendable members therein to extend radially to contact an inner diameter of the lockout sleeve. The lockout sleeve is
20 expanded into substantial contact with the inner diameter of the safety valve, wherein the inner diameter of the expanded lockout sleeve is substantially equal to or greater than the drift diameter of the wellbore.

In one embodiment, a method for locking out a safety valve in a wellbore is provided in
25 which a tubular, or lockout sleeve, having an outer diameter substantially equal to or less than a drift diameter of the wellbore and an expansion tool are placed in the wellbore. The lockout sleeve and expansion tool are landed adjacent the safety valve and a flow tube disposed within the safety valve is located. With the valve in an open position, the lockout sleeve and the expansion tool are positioned within an inner
30 diameter thereof. The expansion tool is energized causing extendable members therein to extend radially to contact an inner diameter of the lockout sleeve. The lockout sleeve is expanded into substantial contact with the inner diameter of the safety valve adjacent the flow tube, wherein the inner diameter of the expanded lockout sleeve is substantially

equal to or greater than the drift diameter of the wellbore.

In one embodiment, an apparatus for locking out a safety valve in a wellbore is provided having a tubular, or lockout sleeve, with an outer diameter substantially equal
5 to or less than a drift diameter of the wellbore. Preferably, the lockout sleeve has one or more surface features. The lockout sleeve is made of a ductile material and the surface features may be slots, holes, ovals, diamonds, perforations, or a combination thereof. Further, an inner diameter of the lockout sleeve is expandable to a diameter substantially equal to or greater than the drift diameter of the wellbore.

10

Some preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1a is a perspective view of an expansion tool;

15

Figure 1b is a perspective end view in section thereof;

Figure 1c is an exploded view of the expansion tool;

20 Figure 2 is a perspective view of an embodiment of an unexpanded lockout sleeve according to the invention;

Figure 3 is a perspective view of the embodiment shown in Figure 2 in an expanded state;

25

Figure 4 is a section view of a flapper section of a subsurface safety valve having an expansion tool and an unexpanded tubular disposed therein;

30 Figure 5 is a section view of the embodiment shown in Figure 4, wherein the tubular is expanded;

Figure 6 is a section view of a flapper type surface controlled subsurface safety valve, having an expanded tubular according to an embodiment of the invention disposed

therein; and

Figure 7 is a section view of a ball type surface controlled subsurface safety valve, having an expanded tubular according to an embodiment of the invention disposed
5 therein.

Figure 2 is a perspective view of an embodiment of an unexpanded lockout sleeve 10 according to the invention. The lockout sleeve 10 has a generally tubular body having an outer diameter (OD), an inner diameter (ID), and a predetermined length L1. The
10 lockout sleeve 10 is preferably made of a ductile material having sufficient properties to resist forces designed to yield the lockout sleeve, yet able to plastically and/or elastically deform during application of such forces to a larger diameter without breaking or rupturing. Preferably, the lockout sleeve 10 has a plurality of slots 16 formed in its wall 18. Alternatively, the lockout sleeve may be a solid tubular without
15 any surface features or have a single longitudinal slot extending the length (L1) of the sleeve. The slots 16 are preferably arranged in a longitudinal pattern in an overlapping fashion to facilitate expansion. However, it should be understood that the slots 16 may be any appropriate shape of configuration to enable the lockout sleeve 10 to expand with the application of a radial force. Other surface features include slits, ellipses,
20 ovals, holes, perforations, irregular shapes, such as dog bone slots, or combinations thereof.

Prior to expansion of the lockout sleeve, the outside diameter 12 of the lockout sleeve 10 is substantially equal to or less than the maximum diameter that will drift to a desired
25 location in the wellbore. After expansion of the sleeve, the inside diameter 14 of the lockout sleeve 10 is preferably greater than or equal to the drift diameter of the wellbore.

Figure 3 is a perspective view of an embodiment of an expanded lockout sleeve 10
30 according to the present invention. The expanded slots 16 form a diamond shape as the lockout sleeve 10 is expanded. In use, the expansion tool 100 is lowered into the wellbore (not shown) to a predetermined position and thereafter pressurized fluid is provided in the run-in tubular 130. In the preferred embodiment, some portion of the

fluid is passed through an orifice or some other pressure increasing device and into the expansion tool 100 where the fluid urges the rollers 116 outwards to contact the wall of the tubular, or lockout sleeve 10, therearound. The expansion tool 100 exerts forces against the wall of the lockout sleeve 10 therearound while rotating and, optionally, moving axially within the wellbore. The result is the lockout sleeve is expanded past its elastic limits along at least a portion of its outside diameter. Gravity and the weight of the components urges the expansion tool 100 downward in the wellbore even as the rollers 116 of the expander tool 100 are actuated. The expansion can also take place in a "bottom up" fashion by providing an upward force on the run-in tubular string. A tractor (not shown) may be used in a lateral wellbore or in some other circumstance when gravity and the weight of the components are not adequate to cause the actuated expansion tool 100 to move downward along the wellbore. The run-in string of tubulars may include coiled tubing and in that instance, a mud motor may be utilized adjacent the expansion tool to provide rotational force to the tool. The structure of mud motors is well known. The mud motor can be a positive displacement Moineau-type device and includes a lobed rotor that turns within a lobed stator in response to the flow of fluids under pressure in the coiled tubing string. The mud motor provides rotational force to rotate the expansion tool in the wellbore while the rollers are actuated against an inside surface of a tubular therearound. Additionally, the run-in string may be replaced by wire (or e-line) line providing electrical energy to an electrical motor and also having the strength to hold the weight of the apparatus in the wellbore. In this embodiment, the electrical motor runs a downhole pump providing a source of pressurized fluid to an expander tool, tractor and/or a mud motor.

Figure 4 is a section view of a flapper section 34 of a subsurface safety valve 39 having an expansion tool 100 and an unexpanded lockout sleeve 10 disposed therein. The lockout sleeve 10 and expansion tool 100 are disposed on the end of a run-in string 130, or coil tubing, which may be used to provide hydraulic fluid to the expansion tool 100. The lockout sleeve 10 and expansion tool 100 are shearably connected and are placed in the wellbore as an assembly. The assembly is lowered to a desired location within the safety valve 39. The flapper section 34 of the safety valve 39 rotates about a hinge pin 36 (shown in an open position). Once the assembly is located at the desired location in the wellbore, the flapper section 34 is opened by the downward force of the assembly

on the flapper section 34. Fluid pressure to actuate the rollers 116 of the expansion tool 100 is provided from the surface of the well through the run-in string 130. The rollers 116 are then actuated and extended radially outward to contact the inner diameter 14 of the lockout sleeve 10. The lockout sleeve 10 is then expanded into substantial contact
5 with the inner diameter of the safety valve 39.

Figure 5 is a section view of the embodiment shown in Figure 4, wherein the lockout sleeve 10 is expanded into substantial contact with an inner diameter of the safety valve 39. The lockout sleeve 10 in its expanded condition is substantially greater than or equal
10 to the smallest inner diameter of the safety valve 39 or a tubular (not shown) disposed between the safety valve 39 and the wellbore. This allows the locked out safety valve 39 to maintain its full open inner diameter and ensure that no flow capacity is lost with the addition of the lockout sleeve.

15 Figure 6 is a section view of a flapper type surface controlled subsurface safety valve 30, having an expanded lockout sleeve 10 disposed therein. Hydraulic fluid is provided to the safety valve 30 via a control line 34 operated by a control panel 32 on the earth's surface. A valve operator 35, such as a rod piston, moves downward in response to increasing fluid pressure in the control line 34. A flow tube 40 moves downward in
20 tandem with the movement of the valve operator 35, thereby opening the flapper 34. A return means 38, such as a spring, a gas charge, or a combination thereof, biases the safety valve 30 in the closed position by acting to urge the flow tube 40 upwards, opposing the force of hydraulic pressure. Lowering (or loss of) the hydraulic fluid pressure in the control line 34 serves to move the flow tube 40 upwards thereby closing
25 the safety valve 30. The lockout sleeve 10 has been expanded into a recess 42 above the flow tube 40, thereby prohibiting an upward movement of the flow tube 40. This causes the flapper to remain in the open position, permanently locking out the safety valve 30.

Figure 7 is a section view of a ball type surface controlled subsurface safety valve,
30 having an expanded tubular according to the invention disposed therein. A valve operator 35, such as an annular piston, moves downward in response to increasing fluid pressure in the control line 34. A flow tube 40 moves downward in tandem with the movement of the valve operator 35, thereby rotating and opening the ball closure

- mechanism 44. A return means 38, such as a spring, a gas charge, or a combination thereof, biases the safety valve 31 to the closed position by acting to move the flow tube 40 upwards, opposing the force of hydraulic pressure. Reduced hydraulic fluid pressure in the control line 34 serves to move the flow tube 40 upwards thereby closing the
- 5 safety valve 30. The lockout sleeve 10 has been expanded into a recess 42 above the flow tube 40, thereby preventing any upward movement of the flow tube 40. This causes the ball 44 to remain in the open position, permanently locking out the safety valve 30.
- 10 As illustrated by the forgoing, the present invention solves problems associated with wellbore valves, especially subsurface safety valves by providing an easy means to permanently opening the valves without substantially restricting the flow capacity of the valve.

CLAIMS:

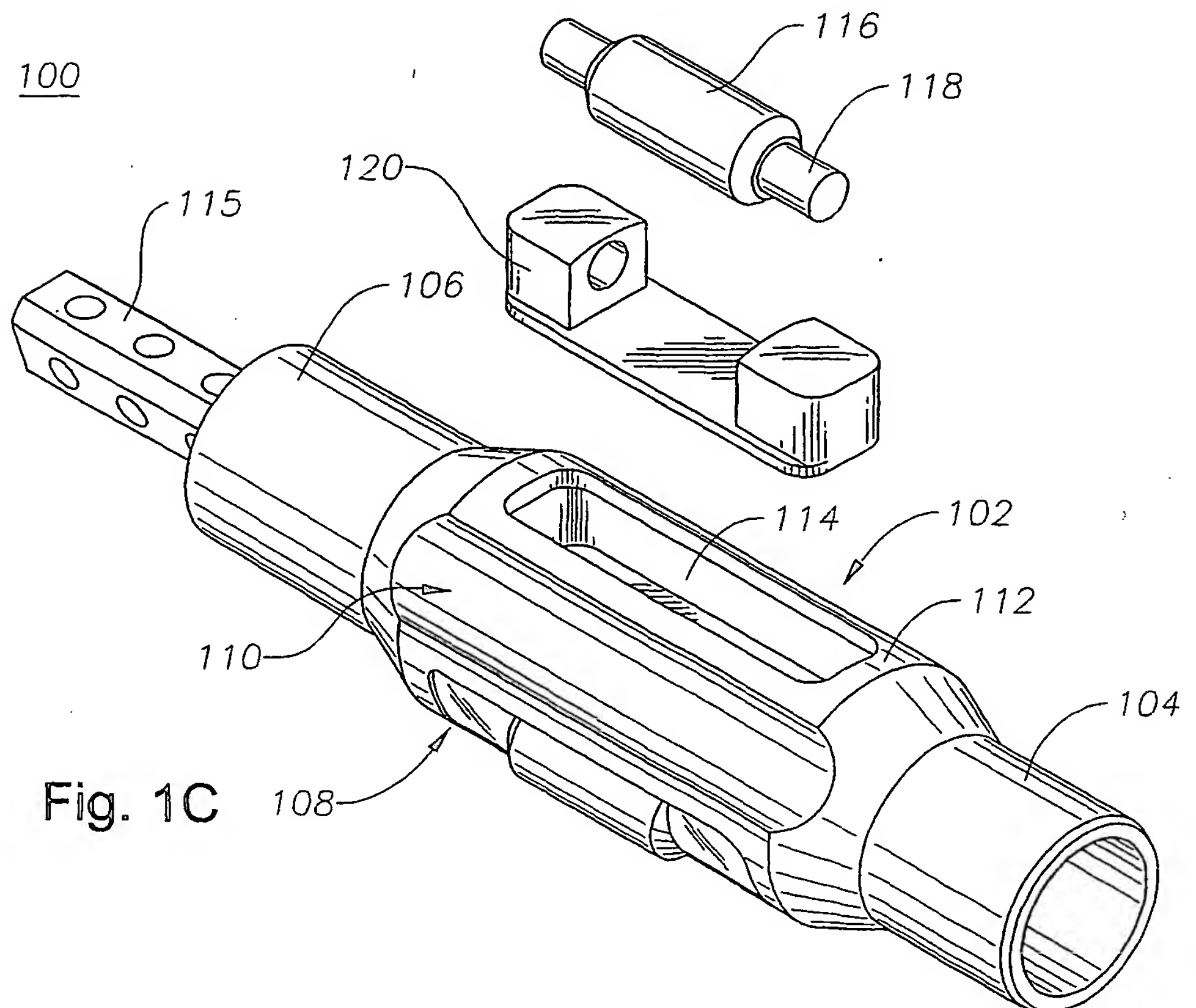
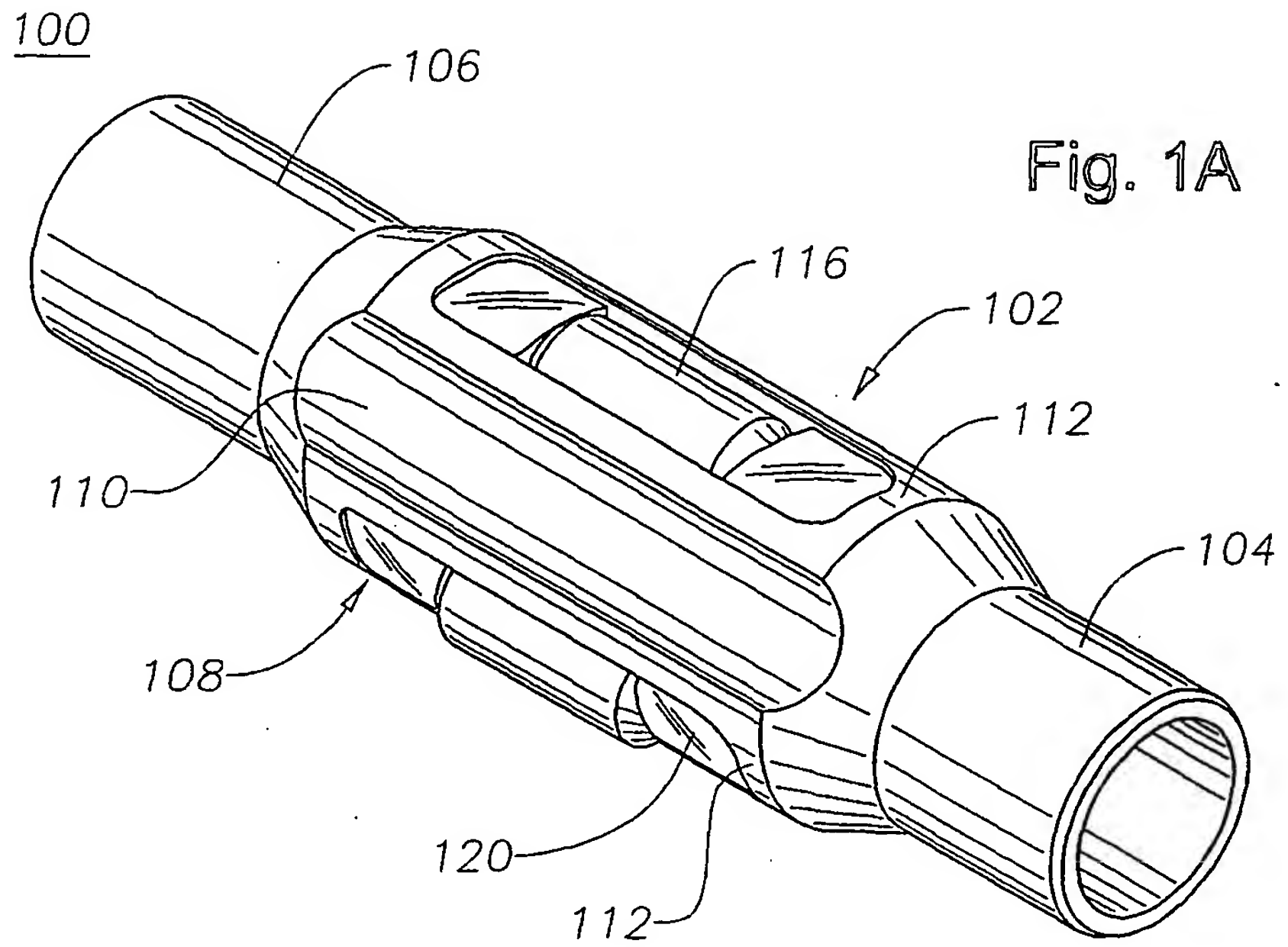
1. A locking assembly for a wellbore valve, comprising:
a cylindrical sleeve, the sleeve insertable into a valve body when unexpanded and
5 constructed and arranged to interfere with a closing mechanism of the valve body when
expanded.
2. A locking assembly as claimed in Claim 1, wherein the sleeve includes walls
with at least one aperture formed therein.
- 10 3. A locking assembly as claimed in Claim 2, wherein the at least one aperture is
slot-shaped prior to expansion and diamond-shaped after expansion of the sleeve.
4. A locking assembly as claimed in Claim 2 or 3, wherein the at least one aperture
15 facilitates the expansion of the sleeve.
5. A locking assembly as claimed in any preceding claim, further including means
for expanding the walls of the sleeve with an outward, radial force.
- 20 6. A locking assembly as claimed in any preceding claim, wherein the expanded
sleeve directly interferes with the closing mechanism.
7. A locking assembly as claimed in any of claims 1 to 5, wherein the expanded
sleeve indirectly interferes with the closing mechanism.
- 25 8. A method of locking a wellbore valve in an open position, the method
comprising:
inserting a cylindrical sleeve into an interior of the valve; and
expanding the sleeve within the interior so that the expanded sleeve interferes
30 with a closing mechanism of the valve, thereby locking the valve in an open position.
9. A method as claimed in Claim 8, further including opening the valve prior to
insertion of the sleeve.

10. A method as claimed in Claim 8 or 9, further including inserting an expander tool into an interior of the sleeve.
- 5 11. A method as claimed in Claim 10, wherein the expander tool includes outwardly extending fluid actuated members.
12. A method as claimed in Claim 11, wherein the sleeve is expanded by radial pressure of the members on an interior surface of the sleeve.
- 10 13. The method any of claims 8 to 12, wherein the sleeve is expanded into direct contact with a closing mechanism.
14. A method as claimed in any of claims 8 to 12, wherein the sleeve is expanded
15 into indirect contact with the closing mechanism.
15. A method as claimed in any of claims 8 to 14, wherein the valve is a flapper valve.
- 20 16. A method as claimed in any of claims 8 to 14, wherein the valve is a ball valve.
17. A lockout sleeve for a safety valve in a wellbore, comprising:
an expandable tubular having an outer diameter substantially equal to or less
than a drift diameter of the wellbore.
- 25 18. Apparatus as claimed in claim 17, wherein an inner diameter of the tubular is expandable to a diameter substantially equal to or greater than the drift diameter of the wellbore.
- 30 19. Apparatus as claimed in claim 17 or 18, wherein the tubular is a ductile material.
20. Apparatus as claimed in claim 17, 18 or 19, wherein the tubular has one or more surface features.

21. Apparatus as claimed in claim 20, wherein the one or more surface features are slots, slits, holes, ovals, diamonds, perforations, or a combination thereof.
- 5 22. A method for locking out a safety valve in a wellbore, comprising:
placing a tubular in the wellbore;
placing an expansion tool in the wellbore;
landing the tubular and the expansion tool adjacent the safety valve;
positioning the tubular and the expansion tool within an inner diameter of the
10 safety valve;
energizing the expansion tool and causing extendable members therein to extend radially to contact an inner diameter of the tubular; and
expanding the tubular into substantial contact with the inner diameter of the safety valve.
- 15 23. A method as claimed in claim 22, wherein the tubular is expanded to a diameter substantially equal to or greater than the drift diameter of the wellbore.
24. A method as claimed in claim 22 or 23, wherein the safety valve is mechanically
20 opened prior to positing the tubular and the expansion tool within the inner diameter of the safety valve.
25. A method as claimed in claim 22, 23 or 24, wherein the tubular and the expansion tool are placed in the wellbore on a run-in string of tubulars.
- 25 26. A method as claimed in claim 25, wherein the run-in string of tubulars is a coiled tubing.
27. A method as claimed in any of claims 22 to 26, further comprising locating a
30 flow tube disposed within the valve, wherein the tubular is expanded into substantial contact with the inner diameter of the safety valve adjacent the flow tube.

28. A method as claimed in any of claims 22 to 27, wherein the tubular has an initial outer diameter substantially equal to or less than a drift diameter of the wellbore.

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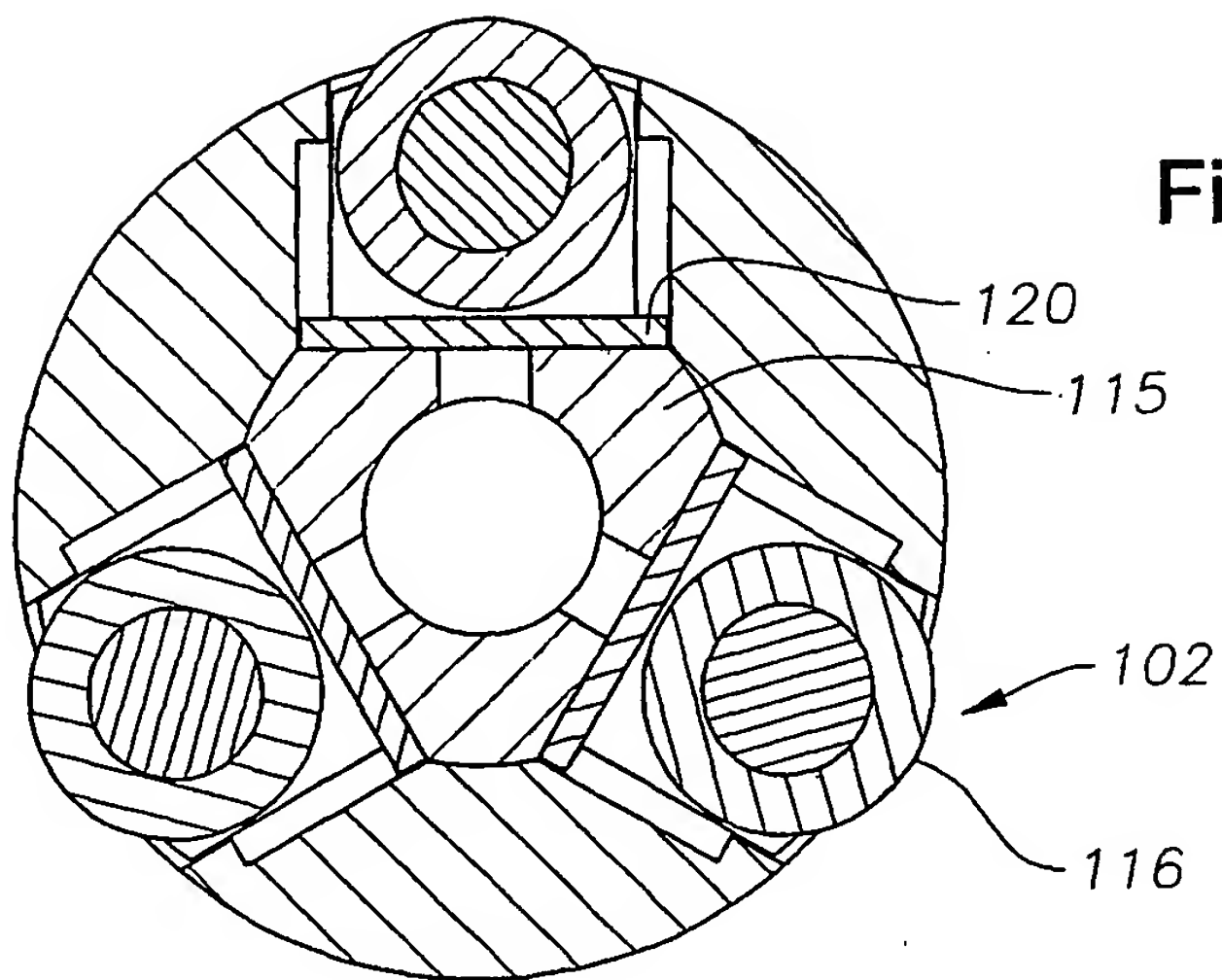
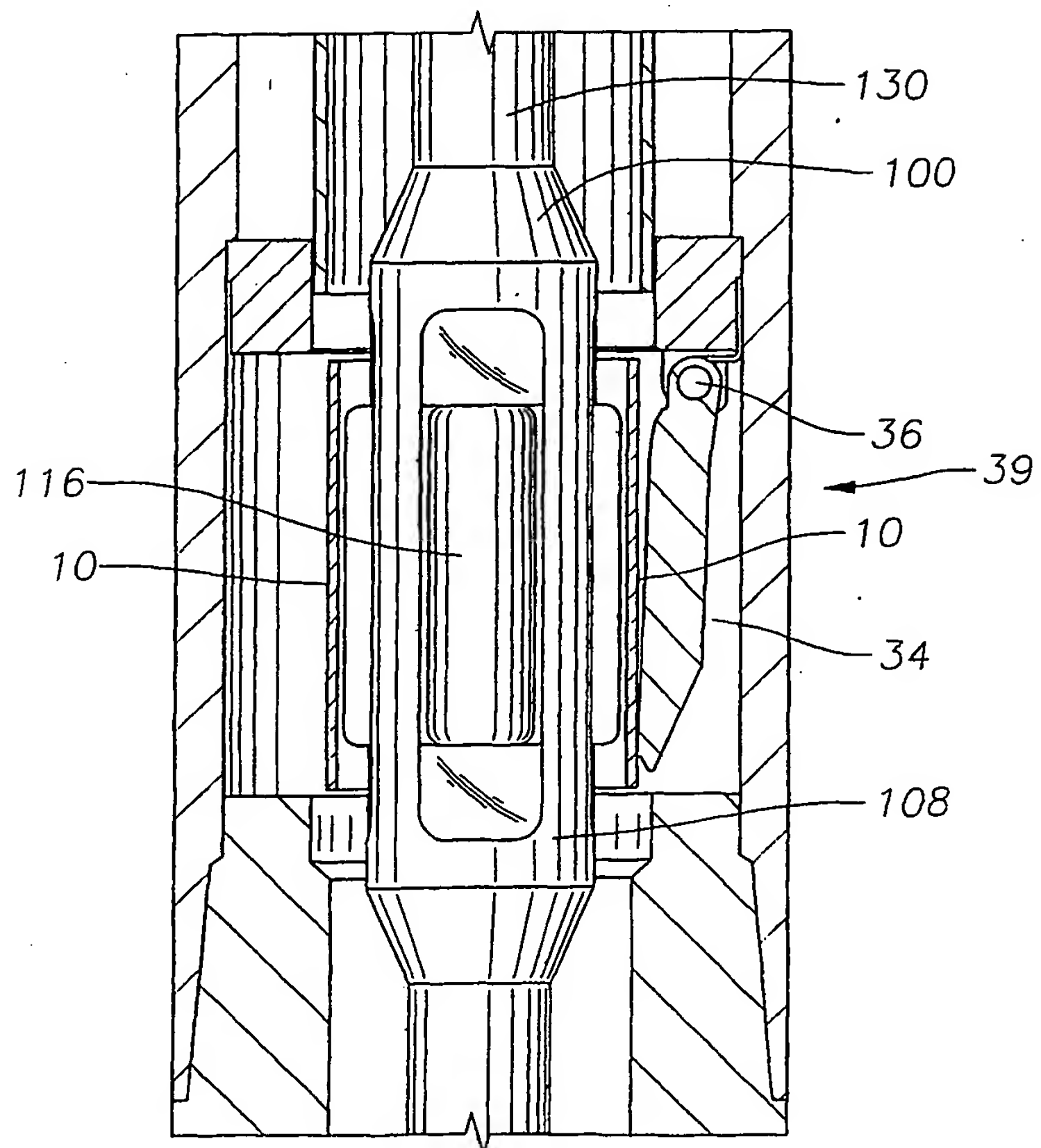


Fig. 1B

Fig. 4



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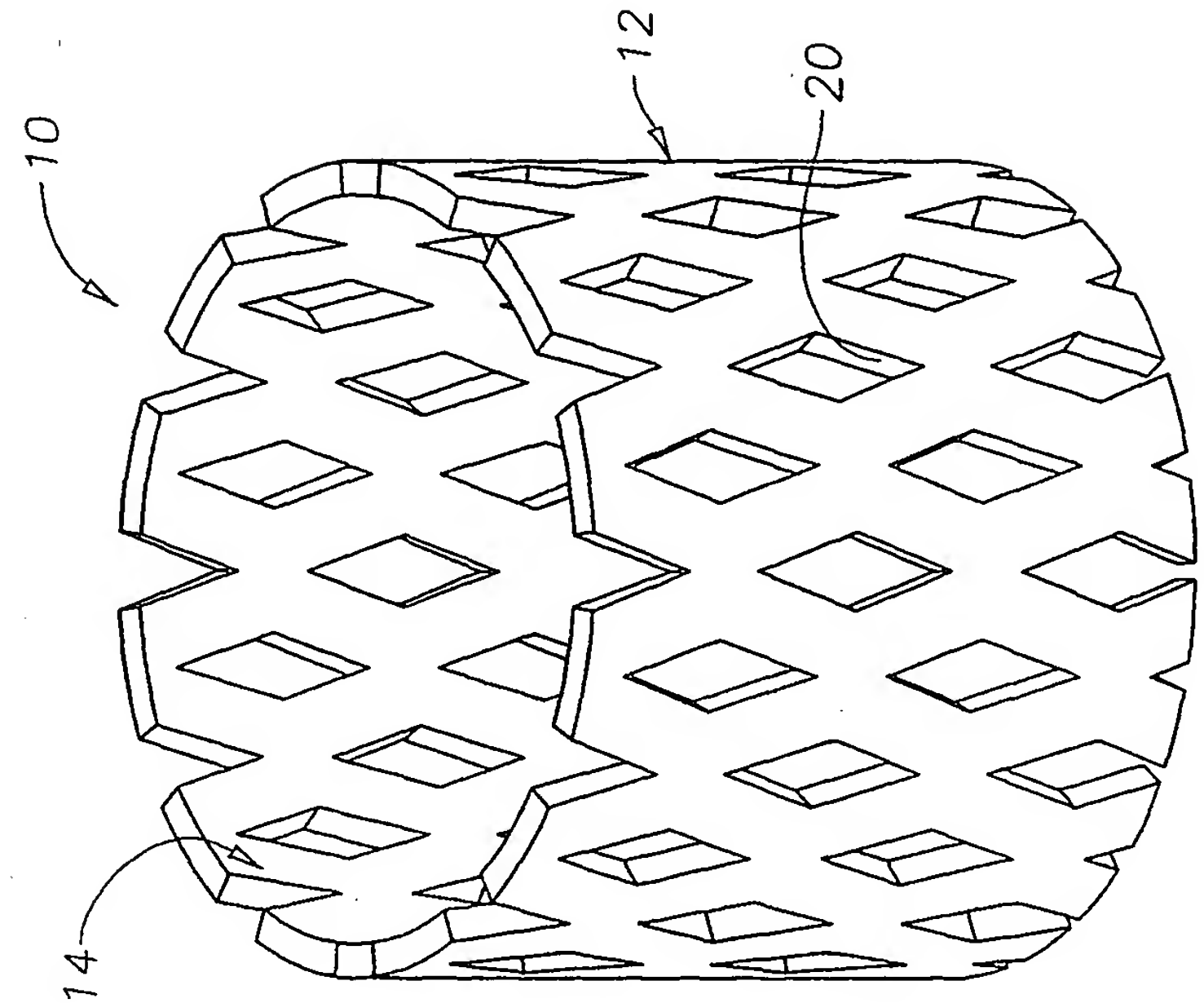


Fig. 2

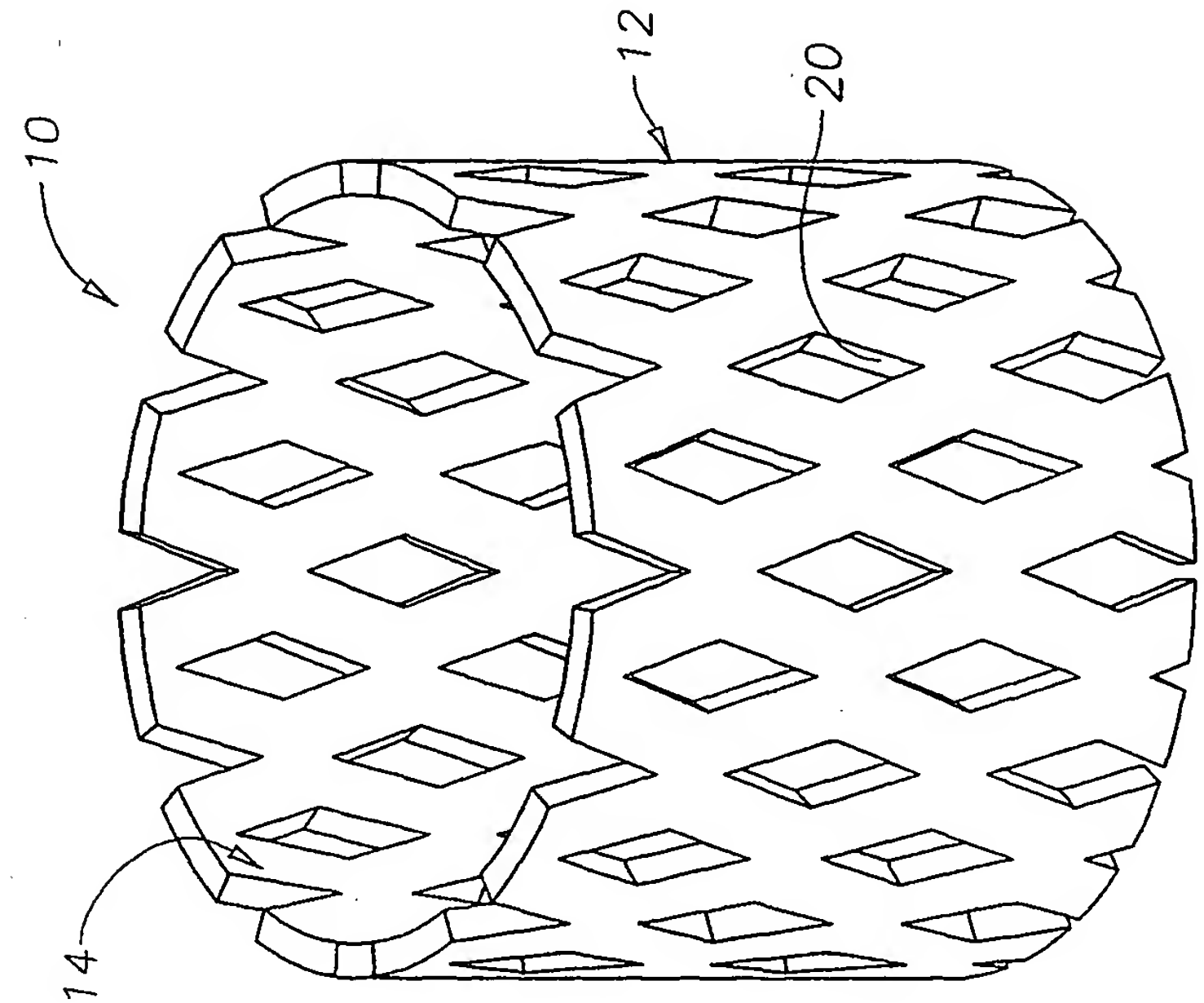


Fig. 3

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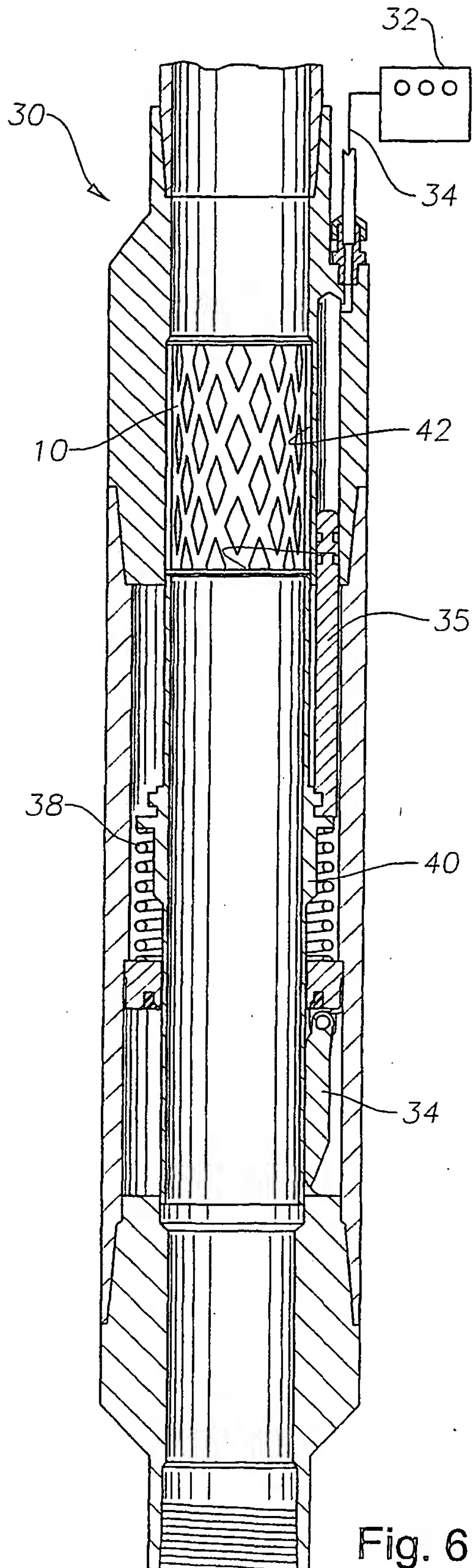


Fig. 6

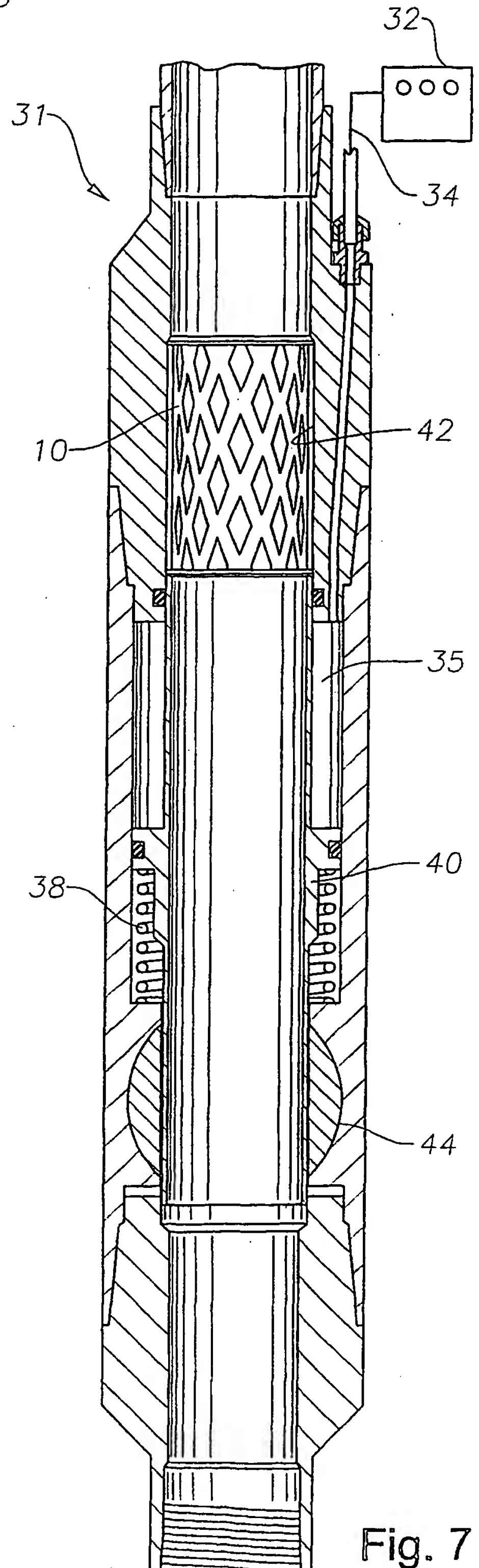


Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 01/04473

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B43/10 E21B23/02 E21B34/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|------------------------|
| X | EP 0 892 148 A (HALLIBURTON ENERGY SERV INC) 20 January 1999 (1999-01-20) column 11, line 53-56 column 12, line 43 -column 13, line 2 column 17, line 57 -column 19, line 37; figures 1,5 | 1,2, 4-11, 13-28 |
| X | US 5 205 355 A (GAY MARION H ET AL) 27 April 1993 (1993-04-27) column 8, line 11 -column 9, line 56; figure 2 | 1,2,4-7, 17-21 |
| A | column 11, line 28-31 | 8,22 |
| X | US 4 597 446 A (HELDERLE PAUL M) 1 July 1986 (1986-07-01) claims 1,2,12 | 1,17 |
| | -/- | |

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| X | <p>US 4 475 599 A (AKKERMAN NEIL H)</p> <p>9 October 1984 (1984-10-09)</p> <p>abstract</p> <p>column 8, line 1-35</p> <p>-----</p> | 1 |

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 01/04473

| Patent document cited in search report | | Publication date | Patent family member(s) | Publication date |
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